atlanta testing
& engineering

October 8, 1976

American Vermiculite Corporation
52 South Executive Park, N. E.
Atlanta, Georgia 30329

Re: Analysis of Crude Vermiculite
Job No. 2273, Lab No. 55019B

Gentlemen:

Atlanta Testing and Engineering Company has completed the requested mineralogical study of the crude vermiculite ore furnished by American Vermiculite Corporation. It is our understanding that the material originated from the Palabora Mine in South Africa. The objective of this study was to determine the minerology of the sample and specifically isolate and identify any fibrous materials which may be present.

GENERAL

On preliminary visual examination, the material furnished appeared to be composed of loose tan and white flakes of typically micaceous vermiculite and a small percentage of light pink to white grains of other mineralogical constituents. The sample was dry (without free water) and relatively lightweight. There was no evidence of fibrous material visable to the unaided eye.

X-RAY DIFFRACTION

In this analysis, the sample was ground into a fine powder and spread uniformly over the surface of a glass slide using a small amount of adhesive binder. The slide was then clamped into a holder and rotated in the path of a collimated x-ray beam while an electron counter rotated about the sample picking up the reflected x-ray beams and recording the reflections as an inked trace on a printed strip chart. The pattern printed on the chart represents the electrons which are simultaneously reflected from each atomic plane within the crystalline structure of a mineral. Each mineral possesses a very distinctive diffraction pattern, and can be accurately identified from the pattern produced in the analysis. X-ray diffraction analysis is limited, however, when more than one or two minerals are present in a sample.

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The x-ray diffraction analysis identified the major constituent of the sample to be vermiculite exhibiting some sodium saturation. Other minerals were revealed but required separation and further study for accurate identification.

OPTICAL ANALYSIS

An isolated sample for the optical analysis was prepared by splitting the bulk sample with a Jones Riffle splitter, and then coning and quartering the material on a clean sheet of glazed paper to obtain approximately 500 to 600 grains of representative material for microscopic examination. The resulting sample was uniformly spread on a flat bottom glass dish overlying a 5 by 5 millimeter grid. A low-power (6x - 20x) stereoscopic microscope was used to identify and count each mineralogical constituent. Grains that could not be identified using the stereoscopic microscope were transferred to immersion grain mounts and examined further. A Vickers M-41 petrographic microscope utilizing polarized light from a tungsten-halogen light source (3100 degree K color temperature), a power magnification (20x - 100x), and immersion oils of differing indices of refraction were used to petrographically determine the mineralogy of these grains (Figures 1 and 2).

Upon completion of this mineralogical identification procedure, the constituents were separated by hand and the relative percentage of each in the total sample was determined. This was done by counting the number of grains of each constituent which composed the total isolated sample and calculating the corresponding percentages.

The constituents composing an isolated sample of 566 separate particles were found to be vermiculite, crystalline quartz, and feldspars in the percentages shown below. Approximately 1% of the sample was not identifiable by the proceeding petrographic methods.

CONSTITUENTS	AMOUNT BY NUMBER OF GRAINS (%)	HABIT
Vermiculite	96.9%	Micaceous to tabular
Feldspars	1.0%	Equant granular
Unknown mineral	1.2%	Massive (very soft)

SCANNING ELECTRON MICROSCOPY

Scanning Electron Microscope (SEM) photomicrographs were made of the raw vermiculite ore sample. SEM photographs are obtained by evaporating a gold palladium coating onto the mineral grains and then forming an image by the scattering patterns of selected electrons directed at the grains.

Relatively low power (45X) was used to present the crude vermiculite ore sample as received (Figure 3). A photograph of higher power (475X) illustrates the intimate laminations characteristic of vermiculite (Figure 4).

Attention was then focused upon the unknown minor mineral observed in the previous analyses. A single grain of the material was isolated and spread out in the microscope field. Careful study of Figure 5 (16,000X) reveals a mineral in the form of long extremely fine needle shaped crystals occurring in bundles of various sizes.

The mineral appears to be a familiar, commercially utilized clay mineral attapulgite, which is also known as palygorskite (Figure 6). For further confirmation, the electron diffraction patterns of the unknown mineral and known attapulgite were compared.

ELECTRON DIFFRACTION ANALYSIS

Electron diffraction analysis is a definitive method of identifying ultra-microscopic crystals without interference from other surrounding minerals. Figures 7 and 8 demonstrate the same basic electron diffraction patterns for the unknown mineral in the vermiculite sample and known attapulgite, respectively.

Considering the similarities of the SEM photomicrographs and the electron diffraction patterns presented above, it is felt that the previously observed unknown mineral constituting the final percentages of the sample of vermiculite is attapulgite.

FURTHER STUDY

Because of the health hazards which have been associated with asbestos, a comparative analysis between the sample of crude vermiculite under study and known asbestos (chrysotile) was performed.

X-Ray Diffraction

For a comparison against the x-ray diffraction pattern of crude vermiculite ore obtained previously in this study (Exhibit 1), a second diffraction pattern was made on a sample consisting only of hand picked vermiculite grains (Exhibit 2). This second diffraction pattern confirms the identification of the vermiculite peaks in the original x-ray analysis.

To introduce asbestos into the study, a portion of the crude vermiculite ore sample was artifically contaminated with chrysotile (Exhibit 3). An x-ray diffraction pattern was then made of this altered sample (Exhibit 4) and

compared with the two previous diffraction patterns. A detailed comparison of these patterns provides additional evidence for the lack of asbestos in the crude vermiculite ore. Since attapulgite was the only mineral found in the crude vermiculite ore which could be considered fibrous and possibly taken for asbestos, additional comparative studies were performed between attapulgite and chrysotile.

Physical Size of Crystal

Figure 9 and Figure 10 (both 115,00X) illustrate the relative size of the crystals of attapulgite from the sample studied and chrysotile, respectively. It is evident from these photomicrographs that the chrysotile crystals are many times more massive than the thin crystals of attapulgite.

Electron Diffraction Analysis

Electron diffraction patterns are proportionally more distinct with increasing quantities of the minerals under study. The light portion of the field of Figure 11 reveals a large grouping of many attapulgite crystals from the ore sample. Figure 11A is the electron diffraction pattern from this mass of crystals. Note the diffuse pattern showing no clear distinction to the light rings. In Figure 12, the light portion of the field isolated a single crystal of chrysotile.

Upon electron diffraction, this single crystal produces a much more distinct circular light pattern (Figure 12A) than did the many crystals of attapulgite.

To further illustrate this comparative difference between the attapulgite of the sample and chrysotile asbestos, electron diffractions were made of the complete fields of both Figure 11 and Figure 12. The multitude of attapulgite crystals in the entire field produced a light pattern (Figure 11B) only slightly more distinct than that of the previous limited field, while the chrysotile whole field pattern which includes only a relatively few crystals, produced a sharp, distinct electron diffraction pattern (Figure 12B).

These distinctions, both in the crystal size and in the electron diffraction patterns clearly show that the mineral present in the vermiculite ore is not chrysotile asbestos.

CONCLUSION

The results of our analysis program confirm that the sample of crude vermiculite ore provided by American Vermiculite Corporation is composed of high grade vermiculite containing only minor traces of impurities. No asbestos was found during this intensive analysis program.

Atlanta Testing and Engineering Company is pleased to have been of service for this analysis.

Respectfully submitted,

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